



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY  
WASHINGTON, D.C. 20460

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Honorable William K. Reilly  
Administrator  
U.S. Environmental Protection Agency  
401 M Street, S.W.  
Washington, D.C. 20460

OFFICE OF  
THE ADMINISTRATOR

Subject: Science Advisory Board Letter Report on Research-in-Progress  
Review of ORD's "Constructed Wetlands for Wastewater Treatment"

Dear Mr. Reilly:

The Constructed Wetlands Subcommittee (CWS) of the Environmental Engineering Committee (EEC) of the Science Advisory Board (SAB) met at EPA's Environmental Research Laboratory (ERL), in Corvallis, Oregon to conduct a Research-in-Progress Review of the Constructed Wetlands for Wastewater Treatment Programs of the Cincinnati Risk Reduction Engineering Laboratory (RREL) and the Corvallis and Duluth Environmental Research Laboratories (ERL) on July 17-18, 1991.

Constructed Wetland Subcommittee Charge

The Subcommittee was charged with the four following tasks:

- 1) Examine the overall research plan, review the current balance among the program areas, review future priorities among these areas, and identify additional areas of research;
- 2) Make recommendations concerning the scope of research including whether free water surface system research should be investigated by the RREL and whether these systems should be applied to uses in addition to municipal wastewater treatment;
- 3) Review the technical, ecological, and system implementation research posed by the RREL and the ERL, identify additional potential problem areas, and make recommendations for prioritization of research in these areas; and
- 4) Consider other Agency research efforts and make recommendations concerning the need for interagency coordination in research and technical development.

## General Observations

The Subcommittee was impressed by the quality and knowledge of the presenting staff and their commitment to the research program. The Subcommittee appreciated the RREL advance material. A Document provided by ERL at the July 17-18 meeting (prepared and published in September, 1990) consisted of a five-year plan for a portion of the research program, but was not included in the staff presentations and is not a subject of this review.

The Subcommittee endorses the Agency move toward development of constructed wetlands, rather than continued utilization or taking over of natural wetland systems for wastewater treatment. Reasons for the Subcommittee endorsement are: 1) protection against degradation and further loss of natural systems, and 2) increased efficiency and cost-effectiveness of wastewater treatment that could result from constructed/managed systems as design, operation and maintenance are refined.

The Subcommittee found that the Agency has an important role in the constructed wetland field which stems from its fundamental responsibility for National water quality protection. It is difficult to understand from this single research review, however, how and where the Agency fits into the constructed wetland research field and how the overall effort is organized within EPA.

The focus of the RREL research program is constructed subsurface wetlands for municipal wastewater treatment, a vital and critical area for research and development. This is a growth area; constructed wetlands are now serving approximately 100 million gallons per day with many design and health questions needing to be answered with research. In the future, smaller municipal systems may come to rely more on constructed wetlands, in some circumstances, due to the promise of cost effective treatment. These circumstances relate to the availability of land and its cost relative to more conventional (i.e., traditional) systems.

If constructed wetlands are to be in the front line of future activities in municipal wastewater treatment, the design specifications to meet effluent limitations must be refined. Municipal systems should be designed with adequate over capacity to allow for growth in the anticipated volume of water for treatment, and consist of parallel systems in order to operate consistently within permitted limits. Parallel components are required because single unit systems cannot be allowed to shut down for maintenance or system failure so that they routinely bypass untreated or incompletely treated wastes, and must have sufficient capacity to treat wide flow ranges and surges. The individual homeowner system would not be expected to meet these capacity conditions for other than peak flow requirements.

It was observed by the Subcommittee that the RREL research had focused on subsurface flow constructed wetlands, due to funding limitations and the specific application of these systems as secondary wastewater treatment after primary sedimentation.

## Constructed Wetland Research Coordination And Funding

During the review it was clear that there is little organization or coordination between ERL and RREL, other than in the database project (which is one of the most important projects of this research program). There must be identification of Agency and program needs to focus on critical and important areas. In this regard, RREL appeared focused on design criteria factors research and guidance manual revision, while the ERL effort appeared fragmented, other than in database development. The ERL-Duluth effort seemed unrelated to the stated research objectives and the laboratory efforts might have been better directed, with funding from the basic wetland research program, to address wetland and wildlife habitat restoration in accordance with recent SAB comments to the Agency in its reducing risk report.

The Subcommittee believes that there is a need for a coherent program and organization within ORD to maximize the return on expenditures and to leverage limited Agency funding, particularly when the level of funding is as low as it is in this case. Additionally, the Subcommittee believes that coordination of other Federal programs needs to occur with respect to pooling of other Federal funds.

Due to the promise of this technology and its increasing level of use, the Agency should prioritize and allocate adequate funding and staff support for further growth areas. These growth areas should include surface flow and open water systems (lagoons) designed for water quality improvement and wildlife habitat value enhancement; integrated systems (subsurface flow with open water systems, as well as these systems in tandem with primary and secondary treatment); urban storm water treatment; other aspects of non-point source, agriculture, mine drainage, road/highway runoff treatment; and, constructed wetlands as polishing/protection of natural wetlands or surface water bodies. Systems for these areas are now in development in several Federal, State and sometimes local agencies, and EPA must be involved because of its fundamental charge for water quality protection. The Agency needs to organize and expand its efforts, develop clear Agency goals and research plans, and implement recommended research with adequate funding. This is particularly important, because there is a national need to develop efficient and cost-effective constructed wetlands for wastewater treatment, particularly urban storm water and other non-point source controls. This fits into the overall Agency goals as identified and or proposed in its Risk Reduction Strategy. In addition, it is possible that wastewater effluent may have a role in rehabilitating drained, mined, or otherwise degraded natural wetlands, although such investigations should not be part of the constructed wetland research plan.

### Need For National Workshop And Refocusing of Agency Priorities

The entire area of Federal constructed wetland research appears fragmented, not just EPA's research program. Coordination is needed, and while there are various mechanisms to achieve a refocusing of Agency priorities, the Subcommittee recommends that EPA cosponsor a national workshop with other Federal and possibly State and local agencies, as well as private organizations (e.g., ASTM and the Water Environment Federation) having similar needs. The workshop should focus on identifying the programs and staff of Federal agencies conducting constructed wetland research and the types of constructed wetlands and their uses. The workshop would provide a forum to standardize definitions and terminology being used in this developing field, identify the types of wetlands being developed, the state-of-the-art technology for each, areas needing further development, and provide the basis for developing potential partnerships which have similar goals to expand cost-effective research in an area with current limited funding. Issues identified at the workshop could help the Agency refocus its priorities in the constructed wetland research program and target where additional funding would provide the greatest benefits.

### Comments Concerning Specific Projects

There are numerous areas for further research within the RREL subsurface flow systems studies which the Subcommittee believes should be considered by the Agency for further funding and investigation. These areas include:

- 1) Basic hydrological research, including flow dynamics, media structure, and the role of particulates in pore plugging;
- 2) Fundamental microbiological research including nutrient treatment dynamics, toxic contaminant treatability, and pathogenic organism fate and transport;
- 3) Treatment efficiency research of other basic water quality parameters beyond BOD, TSS and N, to develop performance criteria (e.g., organic carbon, herbicides, pesticides, pathogens);
- 4) Research into the fate and transport of metals, including basic research in oxidation/reduction relationships and the potential for creating hazardous wastes in sediments due to the sequestering characteristics of constructed wetland systems;

- 5) Determine limits and capabilities of treatability of complex waste streams so that guidelines can be developed for application of constructed wetlands only to appropriate waste streams, that is, ones which will be successfully treated by the system; and,
- 6) Research into the functions and values of constructed wetlands in other geographical localities, including the arid west, and into the full range of potential target wastewater systems such as non-point, urban, and agricultural systems.

Furthermore, in the Tennessee pilot studies:

- 1) The analytical parameters and their frequency of measurement should be expanded in quantitative, statistically valid studies to focus on the kinetics of system function to replace the observational nature of historical data;
- 2) The monitoring study should help design bench-scale experiments on control mechanism research into basic parameters, such as temperature, hardness, and continual versus intermittent flow, which cannot be satisfied by the one field location;
- 3) The monitoring study, with controlled bench-scale experiments, should be integrated with results from the database project to develop research models to further explore kinetics, hydraulic loading rates, treatability, temperature, etc. and analyze design and performance criteria in order to provide a basis for manual redevelopment in design and performance criteria;
- 4) The design studies should be expanded to include aeration control and the role of aerobic/anaerobic relationships in treatment efficiency; and,
- 5) Research should be conducted into the role of aquatic plants and their importance in the system as periphyton substrate, and in particulate removal and potential for providing oxygen to the treatment medium.

It should be noted that there is no similar monitoring of free water surface flow type of constructed wetlands implemented in this research effort. Therefore, most of the information needs for these systems has to be met by the literature database development effort. Some of the preliminary results shown at the review meeting indicate that large variability exists in the existing constructed wetlands design, and that key variables and their importance in the design and performance

for secondary treatment of municipal wastewaters may not be adequately quantified. Again, analysis of variables and improvement in design criteria could be accomplished through development and manipulation of specific system models.

The database effort was regarded by the Subcommittee as very valuable and appears well organized. Additional emphasis should be placed on collection of ecological and wildlife utilization information, which has been extensively studied, especially for surface water systems. It was unclear to the Subcommittee, however, how extensive the coordination between RREL and ERL would be, and how much analysis of the data generated would be made available to RREL in its manual design effort. The database project should be able to provide additional data for progress in kinetics studies, design and performance criteria, and seasonal or other geographic climate data for use in manual development as discussed above in comments concerning the Tennessee studies. Stronger and more systematic coordination between RREL and ERL is recommended. If significant additional funding is not forthcoming, ERL should consider abandoning its low level support for the dairy wastewater project and possibly the ERL-Duluth ecological survey, as well as the acid mine drainage project. Additional comments on these three projects are provided below.

The ERL-Duluth ecological study did not appear to relate to any of the RREL or ERL-Corvallis programs, consisting of single snapshot observations at six open water system wetlands. The project consists of a short-term ecological assessment with limited value for long-term assessment of true system value in wildlife utilization or enhancement. It has been suggested that this project was conducted due to a lack of information on enhanced productivity and wildlife carrying/utilization capacity at open water treatment systems relative to natural wetlands. If this was indeed the project goal, the research should have been focused on system dynamics and productivity investigations in time, rather than snap-shot utilization observations, and could have been funded by the wetland ecological research program instead of the constructed wetland program. Funding for this project would have been better spent in the database project to expand its review of ecological data available in the literature. At the least, this study should have concentrated on evaluation of wildlife utilization of subsurface or onsite household systems in order to be consistent with other areas of field research in this research program. This could include research in problem areas such as pest control (e.g., burrowing and vegetation consumption).

The limited funding of the Oregon State University dairy treatment system did not appear well spent or well defined. The project did not involve research and no product was projected for the expenditure, other than construction of a wetland to aid in dairy wastewater treatment. The dairy already has state-of-the-art treatment, and it was unclear what the ERL staff expected to learn from construction of a wetland at this site. At a minimum, the research program objectives need better focus prior to undertaking demonstration projects such as this. Additional program funding is needed before the current research program

diversifies into project areas such as this. The funding could have been better spent supplementing the database effort or expanding the ecological study effort in subsurface constructed wetland research.

Similarly, while acid mine drainage should be a significant area for research, the limited funding and lack of product for the RREL support of the Soil Conservation Service project appeared to contribute little to overall project goals. The mining industry has numerous (approximately 400 sites) constructed wetlands in operation, and this issue dwarfs the small community individual home system problem with respect to direct effects upon receiving water bodies. The Subcommittee strongly believes that this is an important area of research but suggests that, if recommendations for expansion of research funding in this area cannot be implemented, the Agency should suspend further efforts until adequate funding can be allocated. In fact, the funding would have been better spent in support of a workshop on interagency coordination, and database efforts more central to the goals of the current research program. As noted above, the Subcommittee identified this as an important area for additional research and encourages ORD to consider funding it as a major research effort.

The onsite system monitoring program is a good start in an important development area, although there is some concern that these systems are of limited importance in a national research effort with limited funding. This area needs quantitative research to develop the kinetic and performance data necessary to replace the information currently available only in the unrefereed literature and to determine the efficacy of these systems. The current research program should be expanded to include public health considerations, such as health endangerment of local populations and treatability of pathogenic organisms. In particular, some monitoring should be done with known viruses, such as M3-2, or male-specific coliphage. Future studies should expand investigations of these systems into other geographical areas.

The RREL focus on revision of the design manual and its publication is a sensible and tangible goal. Given the modest funding for the current program, this will undoubtedly lead to only a modest improvement of the manual until the above basic research and model development studies are conducted. Clearly, at current levels of funding, significant advancement in system design cannot be expected. Therefore, the expectations for precision and accuracy of the resulting manual should not be too high, since the current goals are too modest. The expansion of the monitoring program and integration with the database program results, in order to study underlying kinetics and fundamentals suggested above, will ultimately lead to substantial improvement in design and performance of constructed wetland systems and a need for further revisions to the manual.

The goal of the manual should be comprehensive, telling the community that is considering a constructed wetland for municipal wastewater treatment how to select between free water and subsurface flow systems, how to design a system for maximum water quality improvement, and how to take into account ecological

consequences and benefits. Because the current research effort is fragmented, it did not appear that even such a limited objective will be accomplished. For example, the RREL has focused on subsurface flow wetlands while the ERL is only investigating free surface wetlands. Research and its funding should not be allocated this way. The allocation should be made along engineering and ecological lines designed to achieve common objectives.

In summary, the EEC and its Constructed Wetlands Subcommittee strongly supports research in the constructed wetlands field and recommends increased funding for expanded research in a number of critical areas. While some of this review may appear negative in nature, the Subcommittee believes that the quality of staff involved in this program is excellent and the overall effort is commendable. The Subcommittee has identified areas for additional or expanded research, recommends ORD to improve its overall research strategy and organization to guide priority development and coordinate activities at the various laboratories, and increase funding and staffing in this important research area.

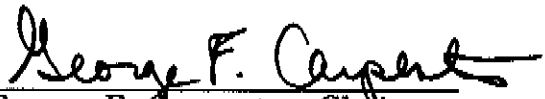
We appreciate the opportunity to assist and provide suggestions in this research-in-progress review. This letter report involves scientific issues of relevance to a program of national significance and the Subcommittee raises issues which need to be considered by the Agency. We look forward to the Agency response.



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